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# SEARCH FOR PERIODICITIES NEAR 59 s IN THE COS-B GAMMA-RAY DATA OF 2CG195+04 (GEMINGA)

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## ABSTRACT

*COS-B data relating to 5 observations in the general direction of  
Geminga, spanning 6.7 years, have been searched for pulsation near  
59 s. The SAS-2 indication is not confirmed.*

1. Introduction. An indication of a 59 s pulsation in the gamma-ray emission from 2CG195+04 (Geminga) was reported by the SAS-2 group (1); it was not considered statistically compelling and confirmation by further experiments was demanded. Early analysis of COS-B data supported the result (2) while later improved statistics did not confirm it (3). Subsequently other authors (4,5) reported detection of a 59 s pulsation in the emission from the direction of Geminga at ultra high gamma- and X-rays. In particular Bignami et al. (5) used a compilation of all the claimed detections to identify Geminga with the X-ray source 1E0630+178, discovered by the EINSTEIN satellite inside the error box of 2CG195+04 (6), although Buccheri et al. (7), after a statistical analysis of all the reported detections, dispute that the identification can be made. Leahy et al. (8), on the other hand, find the X-ray and the UHE results acceptable. Reported below is the analysis of the final COS-B data on Geminga which was observed 5 times for a total of 214 days.

2. The data base used. Table I shows the parameters of the 5 COS-B observations used here. Photons with energy between 50 and 3000 MeV were selected using an energy dependent acceptance cone (9). Their arrival times were transformed from the satellite to the Solar System Barycentre using the position of the X-ray source 1E0630+178, candidate counterpart of Geminga. The precise choice of the position is however not important in this case due to the value of the period investigated.

OBS. no.	START	END	Aspect Angle	Effective Observ. Time (d)	Photons Detected $N_t$ (1)	Expected Background Photons $N_B$	Expected $n_\sigma$ (2)	Period range searched (ms)	no. of steps
1	75/8/17	75/9/17	15.2	18.81	200	88	4.6	141	215
14	76/9/30	76/11/2	0.2	20.60	467	183	12.5	198	321
39	79/2/22	79/4/3	6.7	16.75	341	146	8.0	319	637
54	80/9/4	80/10/17	9.5	12.02	201	87	4.7	397	843
64	82/2/18	82/4/25	6.5	19.21	353	129	10.3	472	1553

(1) The acceptance cone used for selection is defined by  $\Theta_m = 12.5E^{-0.16}$  (Buccheri et al, 1983)

(2) Defined by  $n_\sigma = \frac{f^2}{\sqrt{2(N-1)}} \frac{1-\beta}{8} \frac{(N_t - N_B)^2}{N_t}$  where  $\beta=0.14$  and  $f>0.27$  are deduced from SAS-2 and  $N=20$  is the adopted no. of histogram bins

3. Searched intervals. The value  $P = 59.0074s$  and  $\dot{P} = 2.23 \times 10^{-9} s/s$ , valid at the epoch  $JD = 2441665.5$  (10) have been used as a starting point for the search. We attached to these values the uncertainties  $0.002s$  and  $8 \times 10^{-10} s/s$  respectively and extrapolated to the epochs of the 5 COS-B observations to obtain the actual range of values of the period to use for the search. Fig. 1 shows the extrapolation and table I gives the adopted search intervals together with the number of steps necessary to cover them at a stepsize equal to half a phase shift (also given in table I). These intervals include the range of periods discussed in ref.5. The assumed uncertainty in  $\dot{P}$  is comparable to half phase shift stepsize for the individual COS-B observations and therefore no scanning in  $\dot{P}$  has been done.

4. Predictions. The gamma-ray flux of 2CG195+04 is stable throughout the 9.3 years elapsed between the SAS-2 observation and the last COS-B measurement. Assuming that the pulsed fraction ( $> 27\%$ ) and the duty cycle ( $\sim 14\%$ ) are the same as measured by SAS-2, a lower limit on the signal expected in the COS-B data, using the epoch folding, is given in table I. For a sinusoidal signal the ability to resolve the same pulsed fraction is reduced to the 2-3 sigma level.

5. Analysis and results. The barycentric arrival times obtained in each of the 5 COS-B observations have been folded with the  $P$  value covering the intervals shown in fig. 1 (and table I) and with the SAS-2  $\dot{P}$  value.

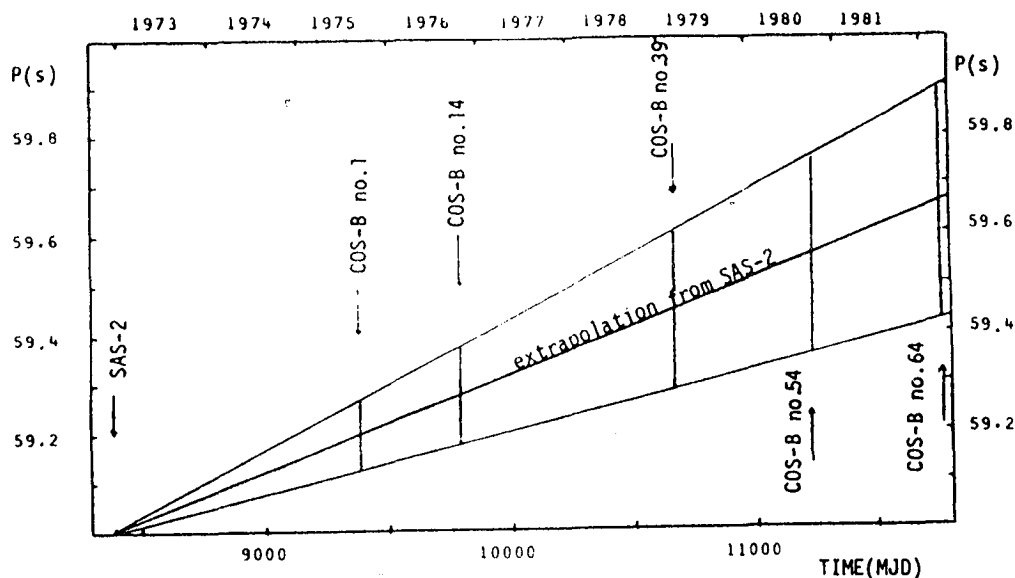


Fig.1 - Period intervals investigated in the present analysis for each of the 5 COS-B observations with Geminga in the field of view

For each of the derived 20-bin histograms, the application of Pearson's test gave the number  $n_{\sigma} = (\chi^2 - 19)/\sqrt{38}$  which is plotted in fig. 2 together with the predictions. The following comments can be drawn:

- a- the highest  $n_{\sigma}$  value is 4.5 corresponding to a chance occurrence probability of  $0.45 \times 10^{-3}$ . Such an effect is expected due to the 3569 trial periods scanned.
- b- the distribution of the  $n_{\sigma}$ 's fits well with that expected from randomly distributed arrival times.
- c- the measured  $n_{\sigma}$ 's are always well below those expected from SAS-2.

We have also attempted to fit the individual photon arrival times with a sinusoidal signal as reported in (5) for the ranges of frequencies implicit in fig.1. A number of peaks in likelihood estimated of the power spectrum were found above the 2-3 sigma level as expected from randomly distributed data.

6. Conclusion. The present analysis which uses all the available COS-B data does not confirm the presence of a 59s pulsation in the gamma-ray flux of Geminga with the signal characteristics reported by SAS-2. For a sinusoidal signal at the modulation level reported in ref. 5 no conclusion can be drawn.

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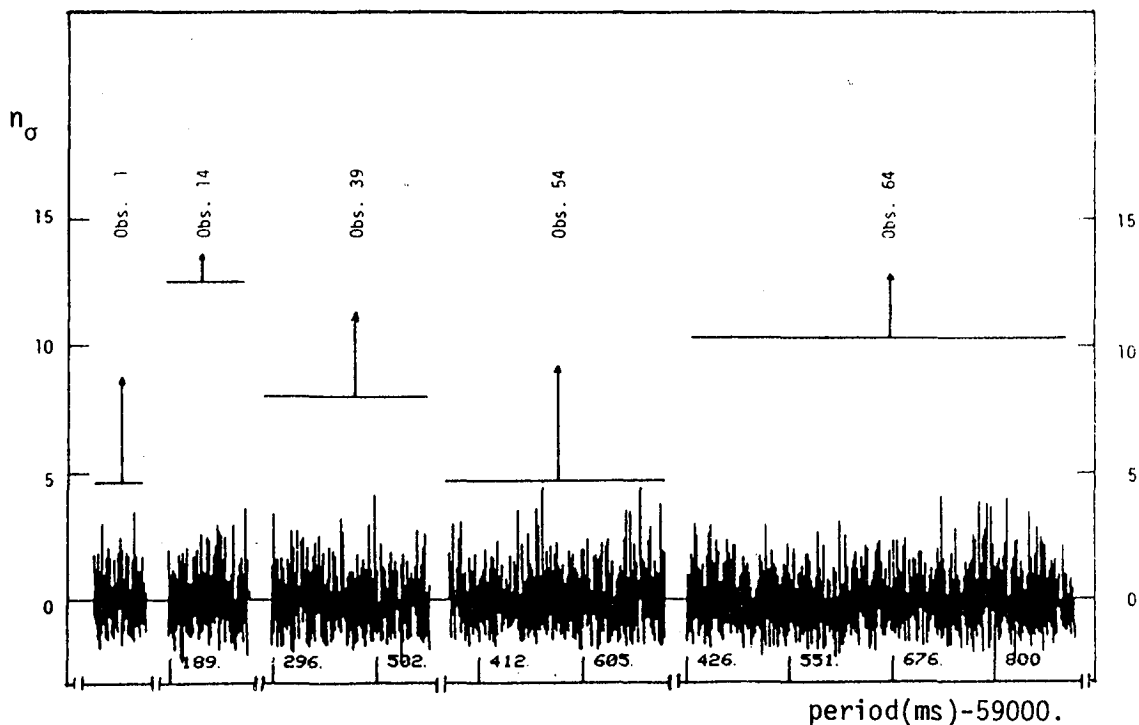


Fig.2 - Values of  $n_{\sigma} = (\chi^2 - 19) / \sqrt{38}$  as derived from the search compared with the predictions

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